

# PATENT SPECIFICATION

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DRAWINGS ATTACHED

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## (54) COOLING DEVICE FOR FILM-PROJECTOR LIGHT-SOURCE UNITS

(71) I, TAISUKE TSUGAMI, of 1-415, Shimoochiai, Shinjuku-ku, Tokyo, Japan, a subject of Japan, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to cooling devices for film-projector light-source units and particularly for those of the type used in high-power film projectors.

Film-projector light-source units of the type described generally include major component parts such as a light-source lamp, a reflector mirror and a casing enclosing such components. As light-source lamps, tungsten lamps are used primarily for midget or small-sized projectors while xenon lamps are preferred for large-sized projectors such as those for theater use.

The present invention is particularly, though not exclusively, applicable to cooling devices for light-source units of the type usable in large-sized film projectors and employing as a light-source a xenon lamp in the range of from 5 KW to 20 KW, and is designed to cool both the reflector mirror facing the light-source, and the light-source box or casing enclosing the light-source lamp and reflector mirror with efficiency thereby to prevent any undesirable rise in temperature of these components of the light-source unit.

Reflector mirrors most widely used in film projectors are generally in two types; one type includes ellipsoidal mirrors made of glass and carrying a vapor-deposition of aluminum or silver and the other type includes so-called cold mirrors which are ellipsoidal mirrors coated with a thin film which reflects visible radiation and transmits infra-red radiation.

Reflector mirrors, being arranged immediately adjacent to the light-source, are heated in use by the radiant energy from the light-source which includes infra-red or heat rays and are thus susceptible to breakage. Particularly in cases of cold mirrors, there is a danger that the film coating on the glass

surface be exfoliated therefrom or the glass body of the mirror itself break under the heat effect of the light-source.

Xenon lamps, usable as a light-source in a film projector, exhibit a color temperature substantially the same as that of the sun and the radiation from xenon lamps includes not only visible light rays but also a large amount of infra-red radiation and a lesser amount of ultra-violet radiation. These radiations are partly absorbed by the glass material of the reflector mirror and converted therein into heat energy, raising the temperature of the mirror. Thus, the temperature of the reflector mirror rises fast as soon as the light source lamp is turned on and falls by natural cooling when the lamp is turned off.

It is said that the reflector mirror is more liable to break in the course of natural cooling than when it is being heated, this, it is supposed, being due to the fact that the rate of natural cooling of the mirror cannot be uniform over its entire surface, giving rise to local temperature differences and hence thermal stress in the mirror material.

In cases of so-called cold mirrors, the film coated over the glass surface of the mirror is liable to separate therefrom making the mirror itself unable to function as a reflector mirror. The film separation is probably due to the fact that the glass material of the mirror and the film material used have different coefficients of thermal expansion.

Another difficulty previously encountered with large-sized film projectors employing, for example, an 8-KW xenon lamp bulb has been an inconvenience that the light-source box surrounding the lamp and the reflector mirror tends to become excessively hot. In the case of an 8-KW xenon lamp, it emits radiant energy of approximately 4 KW and about one half of this amount of energy is constituted by infra-red rays, the rest being comprised of visible and ultra-violet rays. These different rays from the light-source lamp are absorbed in the inside surfaces of the light-source box and raise its temperature. As the box grows hot, it starts to emit heat rays as a secondary radiation

and thus heat the component parts enclosed in the box, including the reflector mirror and electric wiring, and at times the light-source box is itself heated to such an extent as to make the operator unable to touch or feel its outer wall by hand.

The present invention seeks to overcome the abovementioned difficulties and to prevent any substantial temperature rise of the reflector mirror under heat radiation from the light source thereby to prevent breakage of the reflector mirror and separation of the film coating thereon. The invention also seeks to prevent any undesirable temperature rise of the box itself. Accordingly the present invention provides in a light-source unit for a film projector, including a light-source lamp, an ellipsoidal reflector mirror, a casing surrounding said light-source lamp and said ellipsoidal reflector mirror, and an air duct connected to the bottom of said casing axially thereof, a cooling device comprising: (a) means for cooling said reflector mirror, including inner and outer concentric air passages of annular cross section arranged in said air duct to receive cooling air and having respective outlet ends presented to an aperture formed in the center of said reflector mirror, said outlet ends being formed to direct the cooling air leaving said annular air passages outwardly along the inner and outer surfaces of said reflector mirror, respectively; and (b) a double-wall structure forming the peripheral wall portion of said casing which receives infra-red or heat radiation from said light-source lamp directly and through said reflector mirror, said double-wall structure defining therein water jacket means to receive cooling water for circulation therethrough.

For a better understanding of the invention and to show more clearly how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings in which:

Fig. 1 is an axial cross section of a light-source unit embodying the present invention.

Fig. 2 is a view similar to Fig. 1, and showing a modification of the unit shown in Fig. 1; and

Fig. 3 is a fragmentary enlarged cross section of the embodiment of Fig. 1, illustrating the air streams flowing along the inner and outer surfaces of the reflector mirror to cool the latter efficiently.

Referring to Figs. 1 and 2, in which like reference numerals indicate like parts, a light source in the form of a xenon lamp bulb L has such a polar light-distribution characteristic that it emits intense light rays in an angular range defined by straight lines *i* and *j*, which extend at respective angles of  $\pm 45^\circ$  to the horizontal line H drawn through the center of light source. The light rays emitted

outside this range are of very weak intensity and carry only a little heat energy.

In the illustrated embodiments, the reflector mirror 1 is a cold mirror as is conventional with large-sized film projectors. As usual, the cold mirror 1 is made of glass and coated with a multi-layer film so as to reflect visible rays while transmitting infra-red rays. In case the light source bulb L is a xenon lamp, about one half of the radiant energy impinging upon the cold mirror 1 is comprised of infra-red rays, as stated hereinbefore, and the reflector mirror 1 and light-source box 2, 4 are protected against any undesirable temperature rise under such infra-red radiation, as will be described below in detail.

Referring again to Figs. 1 and 2, reference numeral 6 indicates a tubular air duct provided to supply air for cooling reflector mirror 1 and secured to the machine frame 23 by way of a leg member 24. The air duct 6 is also fixed at its top end to the bottom portion 2-3 of the light-source box and connected by way of a conduit 25 to an appropriate blower or other source of cooling air not shown. Arranged in the tubular air duct 6 are concentric tubes including an inner tube 15, an outer tube 17 and a partition tube 19 arranged between the inner and outer tubes with a plurality of spacer elements 22 arranged both inside and outside the partition tube 19 to fix the three tubes relative to each other. At their top ends, these tubes present themselves into or close to a circular aperture 1a, which is formed in the center of the ellipsoidal reflector mirror 1. The inner 15 and outer 17 tubes, in the embodiment shown in Fig. 1, have their respective top end portions 16 and 18 formed to flare outwardly along the inner and outer surfaces of the reflector mirror. In the modification shown in Fig. 2, the inner and outer tubes 15 and 17 are formed with circumferential top flanges 16 and 18, which extend radially outwardly at right angles to the common axis of the tubes.

In either of the Fig. 1 and Fig. 2 embodiments, the intermediate or partition tube 19 is formed adjacent to its top end with a circumferential flange 20, which extends closely to the peripheral edge of the central aperture 1a, formed in the reflector mirror 1.

With the construction, described above, it will be observed that a portion of the air being supplied through conduit 25 and air duct 6 and flowing toward the light source lamp L and the central region of the reflector mirror 1 passes through the inner annular air passage 26 (Fig. 3) defined between the inner and partition tubes 15 and 19 and, under the guidance of the flared top end 16 (Fig. 1) or horizontal top flange 16 (Fig. 2) of the inner tube 15, proceeds in the direction indicated by the arrow *c* in Fig. 3 along the inner surface *a* of the reflector mirror 1. Another

portion of the cooling air passes through the outer annular air passage 27 (Fig. 3), defined between the partition and outer tubes 19 and 17, and, under the guidance of the flared top end 18 (Fig. 3) or the horizontal top flange 18 (Fig. 2) of the outer tube 17, proceeds in the direction indicated by the arrow *d* in Fig. 3 along the outer surface *b* of the reflector mirror 1. In this manner, the reflector mirror 1 though heated by the infra-red radiation from xenon lamp L is effectively air-cooled and safely protected against any substantial temperature rise.

According to the above-described feature of the illustrated embodiments, it will be appreciated that the difficulties previously encountered with light-source units of the type described, including the danger of breakage of the mirror body glass or separation of the film coating thereon, can readily be overcome and thus the service life of the reflector mirror is substantially extended.

Description will next be made of another feature of the illustrated embodiments again with reference to Figs. 1 and 2, in both of which the light-source box is shown as including top and bottom sections and the bottom section has a peripheral double wall, including inner and outer walls 2 and 3, and a bottom double wall, including upper and lower wall 2a and 3a (Fig. 3), both double walls together forming a lower water jacket 12, which receives cooling water from an appropriate pump or other water source through an inlet conduit 7. Preferably, black frosting paint is applied to the inner surface of the inner wall 2 to enable the latter to absorb infra-red radiation with efficiency. With this construction, it will be readily appreciated that any infra-red or heat radiation emitted by the light source L and transmitted through the reflector mirror 1 is effectively absorbed by the water circulating through the lower water jacket 12 of the light-source box.

In order to enable the upper section of the light-source box to absorb those infra-red rays which proceed outwardly upward from the lamp L and are not intercepted by the reflector mirror 1, the upper peripheral wall portion of the light-source box is also of a double-wall structure substantially the same as that of the lower box section 2-3 and includes an inner and an outer wall 4 and 5, defining therebetween an upper water jacket 13. The double-wall or jacket structure is mounted on the lower box section by means of a plurality of support brackets 14 secured to the outer wall 3 of the lower water jacket 12.

A curved pipe section 8 is provided to communicate the top portion of the lower water jacket 12 and the adjacent bottom portion of the upper water jacket 13, thus

enabling supply of the cooling water from the lower to the upper water jacket. The cooling water, circulating through the upper water jacket 13, leaves it through an outlet 9 fixed to the top end of the jacket 13 and recirculates. It is desirable that the inner surface of the inner wall 4 of the upper water jacket 13 is also frosted by black painting.

The upper water jacket 13 should have a height exceeding the level  $i_0$ , at which the 45° rays from lamp L strike the inner wall of the jacket, as shown in Fig. 1, in order to prevent any intense rays from the light source from overflowing the peripheral wall of the light-source box.

As shown in Figs. 1 and 2, the reflector mirror 1 is supported along its periphery on a mounting frame 10 by means of a fixture 11, the mounting frame 10 being fixed to the top end of the lower water jacket 12 by screw means not shown.

The divided structure of light-source box, including the upper and lower water jackets interconnected at the level of mounting of the reflector mirror, is advantageous in that it facilitates the interchanging of the light-source bulb and/or the reflector mirror, which is usually required in use of film projectors.

In the light-source box constructed as described above, it will be readily appreciated that the radiant energy transmitted through the reflector mirror 1 and principally comprised of infra-red rays is absorbed by the lower water jacket 12 while the infra-red or heat rays as included in the direct radiation upon the upper section of the light-source box are absorbed by the upper water jacket 13 and thus any undesirable temperature rise of the light-source box is effectively prevented by means of the water circulating through the water jackets.

Although a few embodiments of the present invention have been illustrated and described, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the scope of the appended claims.

#### WHAT I CLAIM IS:—

1. In a light-source unit for a film projector, including a light-source lamp, an ellipsoidal reflector mirror, a casing surrounding said light-source lamp and said ellipsoidal reflector mirror, and an air duct connected to the bottom of said casing axially thereof, a cooling device comprising: (a) means for cooling said reflector mirror, including inner and outer concentric air passages of annular cross section arranged in said air duct to receive cooling air and having respective outlet ends presented to an aperture formed in the center of said reflector mirror, said outlet ends being formed to

5 direct the cooling air leaving said annular air passages outwardly along the inner and outer surfaces of said reflector mirror, respectively; and (b) a double-wall structure forming the peripheral wall portion of said casing which receives infra-red or heat radiation from said light-source lamp directly and through said reflector mirror, said double-wall structure defining therein water jacket means to receive cooling water for circulation therethrough.

10 2. A cooling device as claimed in Claim 1, in which said inner and outer annular concentric air passages are defined by a partition tube arranged between inner and outer concentric tubes arranged axially in said air duct, the outlet end portions of said inner and outer tubes being flared outwardly and the partition tube having the peripheral edge of its end adjacent the outlet end portions of said inner and outer tubes positioned close to the periphery of said aperture in said reflector mirror so that the cooling air streams passing through said inner and outer annular air passages are directed to proceed along the inner and outer surfaces of said reflector mirror, respectively.

15 3. A cooling device as claimed in Claim 1, in which said inner and outer annular concentric air passages are defined by a partition tube arranged between inner and outer concentric tubes arranged axially in said air duct, the outlet end portions of said inner and outer tubes being formed at their outlet ends and adjacent to the central aperture in said reflector mirror with

respective radially outwardly extending circumferential flanges and the partition tube having the peripheral edge of its end adjacent the outlet ends of said inner and outer tubes positioned close to the periphery of said central aperture in said reflector mirror so that the cooling air streams passing through said inner and outer annular air passages are directed to proceed along the inner and outer surfaces of said reflector mirror, respectively.

4. A cooling device as claimed in any one of the preceding claims, in which said casing comprises a lower water jacket defined in a double-wall structure forming that peripheral portion of said casing which receives infra-red rays as emitted by the light source and transmitted through said reflector mirror and an upper water jacket defined in another double-wall structure forming that peripheral portion of said casing which receives infra-red rays directly from the light source, said lower and upper water jackets being interconnected by a communicating tube with an inlet tube and an outlet tube for cooling water being connected to said lower and upper water jackets respectively.

5. A cooling device substantially as hereinbefore described with reference to, and as shown in the accompanying drawings.

HASELTINE, LAKE & Co.,  
Chartered Patent Agents,  
28 Southampton Buildings,  
Chancery Lane,  
London, W.C.2,  
Agents for the Applicant.

Fig. 1.

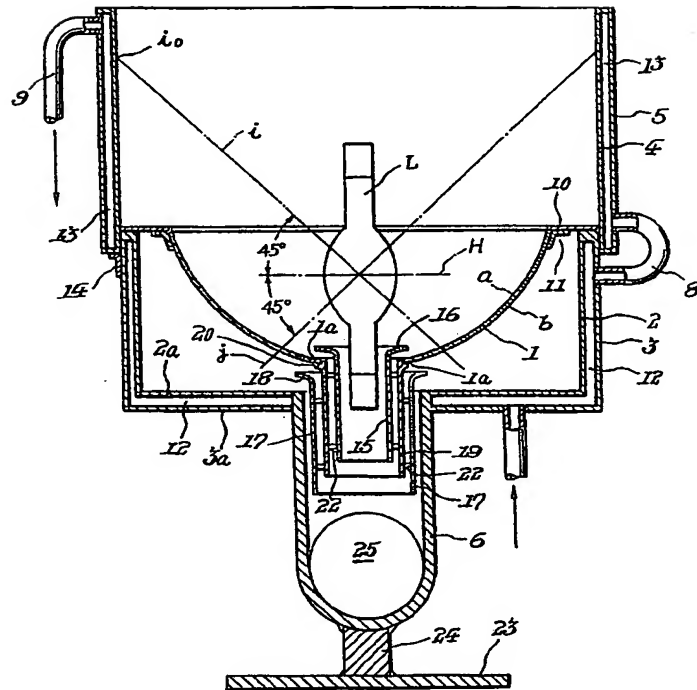
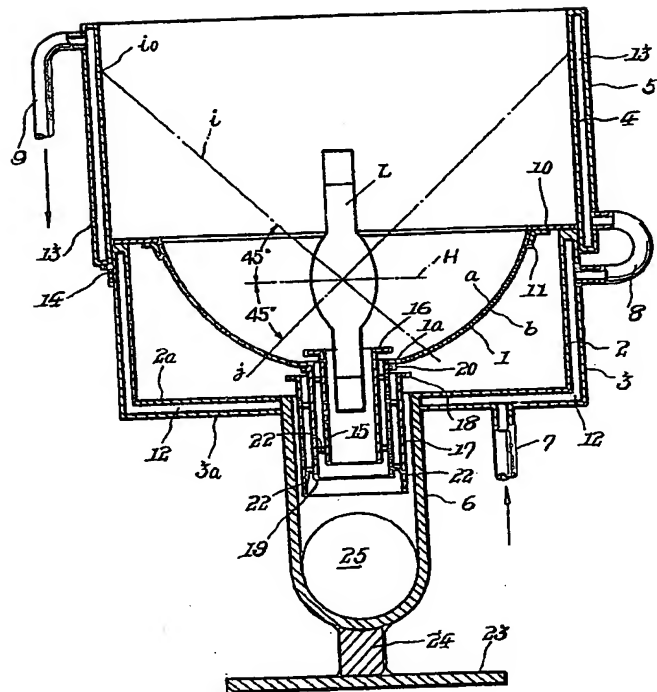


Fig. 2-



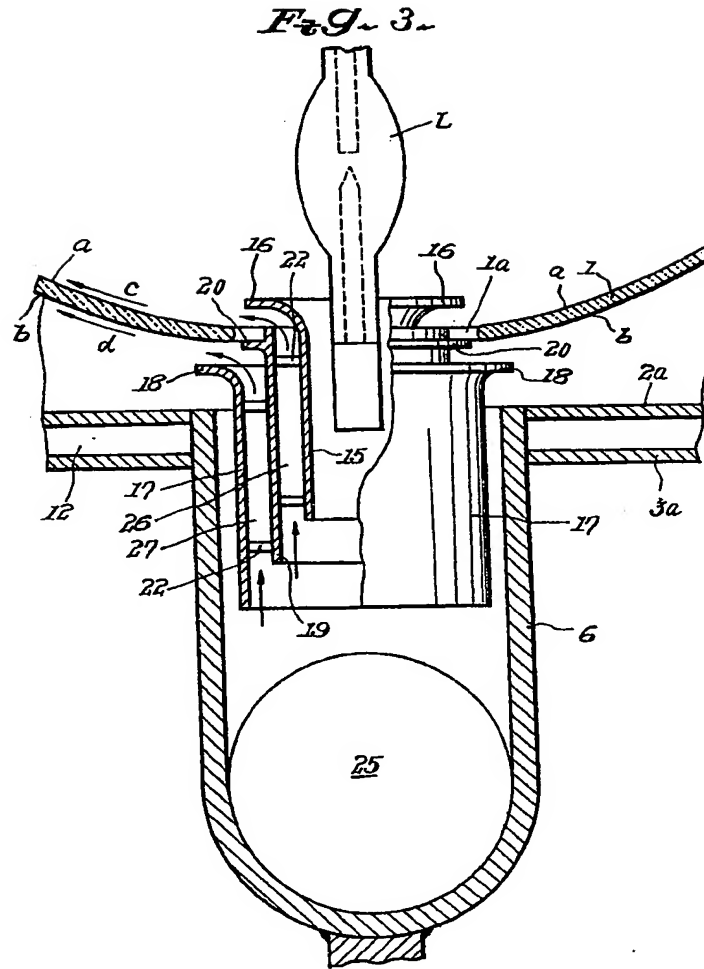
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COMPLETE SPECIFICATION

3 SHEETS

This drawing is a reproduction of  
the Original on a reduced scale

Sheet 3



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